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EMORANDUM REPORT No. 949

DECEMBER 1955

**Provisional Probabilities Of
Incapacitation By A Caliber 0.30
Rifle-Bullet, Ball M2 (U)**

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ABERDEEN PROVING GROUND, MARYLAND

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PROVISIONAL PROBABILITIES OF INCAPACITATION BY A CALIBER
0.30 RIFLE-BULLET, BALL M2 (U), ⁴⁻²

(10) by Theodore E. Sterne and
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BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 949

TESterne/AJDziemian/mjf
Aberdeen Proving Ground, Md.
December 1955

PROVISIONAL PROBABILITIES OF INCAPACITATION BY A CALIBER
0.30 RIFLE-BULLET, BALL M2 (U)

ABSTRACT

Provisional and rough estimates are given of the probability that random hits, by a caliber 0.30 rifle-bullet, Ball M2, will incapacitate men. The estimates are based on estimates by Dr. A. J. Dziemian of the Biophysics Division at Edgewood of the fractions of total projected body area on which hits would result in particular types of disability within times of 30 seconds, 5 minutes, and 30 minutes after wounding. The duties of the target troops are those either of infantry in assault, of infantry on the defensive, of infantry in reserve, or of supply troops. At ranges below 300 yards the probability that a random hit will incapacitate an infantryman in assault within 30 seconds is found to be about 0.61, within 5 minutes 0.73, and within 30 minutes 0.89. Against defensive troops the probabilities are somewhat lower, against reserve and supply troops somewhat higher.

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1. INTRODUCTION

The numerical probability that a random hit by a rifle-bullet will incapacitate a soldier has long been needed for effectiveness and operational studies, as well as for purposes of design. No published incapacitation criterion appears to be appropriate. The availability of some reasonable numerical criterion, even if it is rough and provisional, is in particular currently desirable in view of the possibility that dart-firing hand-weapons may be effective in combat. It is necessary to know how effective conventional bullets would be, in comparison with the novel weapons in order to determine the desirability of the novel hand-weapons.

Some discussion of prior wounding and incapacitation criteria may be desirable. An old criterion of wounding power is the 58-foot-pound rule which states in its crudest form that missiles with 58 foot-pounds of kinetic energy do not kill, and that those with more than 58 foot-pounds do kill. This criterion, which appears to have been borrowed from a more plausible doctrine employed by the German Army¹ at the beginning of the present century, was perhaps never intended to be more than a rule of thumb applicable to lead spheres weighing about half an ounce and about half an inch in diameter. A scientific study² by a French Officer, Colonel Journée, did not particularly support a 58-foot-pound rule rather than a 35-foot-pound or a 115-foot-pound rule. Colonel Journée's program, fired through human and equine corpses, covered a range of weights and velocities of various lead and jacketed projectiles without reaching any single specific, numerical, energy criterion. Reflection about some generally recognized wounding situations indicates that no simple energy criterion can be generally valid. A two-hundred-pound football player, falling three feet upon a tough opponent and hitting him with 600 foot-pounds of kinetic energy,

¹ H. Rohne, Schiesslehre für Infanterie, 1906, p. 68, "To put a man out of action, according to the views prevailing in the German Artillery, a kinetic energy of eight meter-kilograms is sufficient".

² Colonel Journée, Revue d'Artillerie, Volume 70, April-September 1907.

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frequently causes no injury or incapacitation at all. On the other hand a mere woman, pushing a dagger with a force of approximately twelve pounds for a distance of about six inches into a man's chest, can kill him by an expenditure of only about six foot-pounds of energy. It would be unnecessary to argue here against the general validity of a rule so clearly inconsistent with experience and apparently based upon no scientific data, were it not for the fact that a 58-foot-pound "rule" is still used by some weapon analysts. Although roughly applicable to unstabilized fragments of particular weights, the "rule" is particularly inapplicable to darts with knife-like cutting fins and may be inapplicable to bullets.

Measurement of the wounding power of missiles in terms of their penetration through wood has provided a still older, and perhaps superior, criterion. But the one-inch value through pine that is usually used appears to rest upon no more valid a foundation than some Danish experiments, through pine and into live horses, performed sometime before 1867 when they were quoted without detailed reference by Brevet-Colonel J. G. Benton in a textbook³ intended for cadets of the U.S. Military Academy. Projectiles that would penetrate 0.31 inches of pine were said to produce only slight contusions of the skin; projectiles that would penetrate .63 inches of pine would produce dangerous but not disabling wounds; projectiles that would penetrate 1.2 inches of pine would produce very dangerous wounds. Since the date of the Danish experiments must have been earlier than 1867, it appears possible that the projectiles referred to had diameters of the order of 0.7 inches, a common caliber for military muskets in the early nineteenth century.

Quantitative scientific work appears to have started with Burns and Zuckerman in England⁴ who made an analysis of the quantitative

³ Brevet - Col. J. C. Benton, Major, Ord. Dept., "Ordnance and Gunnery", D. Van Nostrand, New York 1872, Copyright 1867.

⁴ Burns, B. D., and S. Zuckerman. The relationship between striking velocity and the damage caused by a 3/32 inch steel ball. Gr. Brit., Ministry of Home Security, 1941, R. C. Report No. 232.

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requirements for wounding and by Gurney⁵ who suggested in 1944 from hydrodynamical considerations that mv^3 might be a more suitable criterion than kinetic energy for the ability of projectiles to wound humans. Work was also carried out by the Princeton Department of Biology under the auspices of the National Research Council, of which an important report was made by McMillen and Gregg⁶. McMillen and Gregg classified wounds into those that were "light" and into those that were "either fatal or severe". The latter class of wound would be caused, they assumed, by projectiles' reaching certain vulnerable regions inside the body after traversing protecting layers of skin, soft tissue, and bone. By making use of the measured retardations of steel balls in skin, soft tissues, and bone and by employing the known geometry of the body and its organs they arrived at numerical probabilities that random hits, by steel balls on a human target, would cause fatal or serious wounds.

Since the McMillen and Gregg results related only to spheres, some generalization was necessary before the results could be applied to non-spherical fragments. The generalization, based upon equivalent penetrations, was made⁷ in Ballistic Research Laboratories Technical Note No. 370. The fragments contemplated were non-stabilized.

Experiments performed in 1951 by the Biophysics Division, Chemical Corps Medical Laboratories, at the Army Chemical Center at the request of the Ballistic Research Laboratories resulted in rough numerical probabilities that random hits on a man by non-spherical, non-stabilized fragments would cause incapacitation. These early experiments appear

⁵Gurney, R. W. A New Casualty Criterion. BRL Report No. 498, 1944.

⁶McMillen, J. H., and J. R. Gregg. The energy, mass and velocity which is required of small missiles in order to produce a casualty. Missile Casualties Report No. 12, 1945, National Research Council, Division of Medical Sciences, acting for the committee on Medical Research, Office of Scientific Research and Development.

⁷T. E. Sterne, "A Provisional Casualty Criterion", BRL Technical Note No. 370, March 1951.

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to have been the first incapacitation, rather than wounding experiments, to have been carried out with fragments and live animal targets. The wounds were assessed in terms of the probable incapacitation that they would have caused in men, although the results were not transformed from the geometry of the test animals employed (goats) to the geometry of men. Although the results were rough they were largely experimental and were therefore objective in a manner in which no previous incapacitation data had been. The results were cast into a form suitable for quantitative use in weapon evaluations by one of the authors⁸ in Ballistic Research Laboratories Technical Note No. 556 and⁹ in Ballistic Research Laboratories Memorandum Report No. 591. The experimental data employed were published¹⁰ in Chemical Corps Medical Laboratories Research Report No. 99.

The preceding historical account leads one to the formal incapacitation studies that have been carried out for several years by the Biophysics Division. In May, 1952, a formal cooperative program was agreed upon by the Chemical Corps, Medical Services, and Ordnance Corps to determine by experiment the numerical probabilities that a man would reach a specified level of incapacitation after he had been struck at random by fragments, bullets, or blast waves having specified physical characteristics. Basic incapacitation studies have been carried out, under the agreement, by the Biophysics Division, Chemical Corps Medical Laboratories, on non-stabilized fragments of various sizes. This work has been performed much more carefully and deliberately than any previous incapacitation work, and the complete

⁸ T. E. Sterne, "Provisional Criteria for Rapid Incapacitation by Fragments". BRL Technical Note No. 556, November 1951.

⁹ T. E. Sterne, "Provisional Criteria for Fatal or Severe Wounding by Fragments". BRL Memorandum Report No. 591, February 1952.

¹⁰ C. M. Herget, M. D. Blackburn, H. R. Fiege, M. Ladd, "Field Studies on Wounding and Incapacitation by Small Fragments". Chemical Corps Medical Laboratories Research Report No. 99, January 1952.

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results of the studies on the first two fragments to be experimented with, namely an 0.85-grain steel sphere and a 16-grain steel cube, have already been published.^{11, 12, 13}

2. THE EDGEWOOD INCAPACITATION EXPERIMENTS AND CONCEPTS, AND SOME RESULTS

Fragments of known material, shape, mass, and striking velocity are fired from guns at experimental animals and the wounds are carefully studied. Hits are obtained on all important regions, and through all important body organs. The wounds are medically studied. The rates of loss of velocity by similar fragments as they traverse known thicknesses of skin, muscle tissue, bone, and other types of body tissue are independently measured by special retardation experiments. Next, by the help of detailed anatomical drawings, the surface of the human body is divided conceptually into small areas on which the consequences of impacts, by individual fragments, are separately considered.

For each position of fragment impact that is contemplated, the tissues and structures that would be hit are predicted along with the remaining velocities of the fragment. From the nature of the structures traversed, and from the remaining velocities along the path of the fragment, the severity and nature of the human wound that would result are predicted on the basis of the medically studied wounds in the test animals. This is done for all areas of the body surface, and for a number of different directions of impact.

¹¹ H. Fiege, L. Angelone, M. A. Vaughn, A. J. Dziemian, "Incapacitation Produced by a 0.85-Grain Steel Sphere at 3800 Feet per Second". Chemical Corps Medical Laboratories Research Report No. 246, February 1954.

¹² H. Fiege, L. Angelone, M. A. Vaughn, A. J. Dziemian, "Wound Ballistics of the 0.85-Grain Steel Sphere". Chemical Corps Medical Laboratories Research Report No. 264, April 1954.

¹³ R. A. Gould, M. A. Vaughn, E. G. Worthley, "Wound Ballistics of the 16-Grain Steel Preformed Fragment (U)". Chemical Corps Medical Laboratories Research Report No. 393, August 1955.

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On the basis of experience with the wounded test animals, and of surgical or medical experience with human incapacitation by wounds, wounds of specific ages are classified into Functional or Disability Groups. Wounds are characterized by their location, by the types of tissues and by the identity of organs or other structures traversed, as well as by the severity and type of damage. The Functional or Disability Groups, on the other hand, are defined in terms of incapacitation, as related to the behavior of the extremities. In the Edgewood results relating to 0.85-grain spherical fragments 10 Functional Groups were employed, defined in Table II of Reference 12, and reproduced in this report as Table 1.

In Reference 13, relating to the 16-grain steel cube, 16 Disability Groups were employed, defined in Table I of Reference 13, reproduced in this report as Table II.

The difference between the definitions of the Functional Groups in References 11 and 12 on the one hand, and of the Disability Groups in Reference 13 on the other is understood to have been due to a natural process of evolution that permitted Dr. Gould, the principal medical assessor in the 16-grain studies, to employ a somewhat more highly refined classification than the system that had been pioneered by his predecessor, Dr. Herbert Fiege, for the 0.85-grain studies. The 0.85-grain workers employed 10 Functional Groups, while the 16-grain workers employed 16 Disability Groups.

"Loss" in Tables I and II means loss of the use of an extremity, and does not necessarily involve the structural loss of the extremity, or even the wounding of the extremity. An explanation, by the use of an example, of the concepts of "fine" and "coarse" muscular coordination has been suggested by Dr. Herget. We have all of us, at one time or another, sat in such a position that the blood supply to a leg was interfered with, and the leg "went asleep". In this state we can still hobble about - i.e. we still have coarse function. We would not be able accurately to kick a football with that limb - fine function is temporarily absent.

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A particular wound, after a certain time, may be evaluated as falling into a particular Functional Group, for example into Fiege's Group IV. At a later time the impairment of functioning of the extremities, due to the same wound may have become more serious and at the later time the wound may thus fall into a new Functional Group, for example VII. The

TABLE I

FUNCTIONAL GROUPS ASSIGNED TO WOUNDS BASED ON THE EFFECT ON THE EXTREMITIES

FUNCTIONAL GROUPS	BEHAVIOR OF THE EXTREMITIES*
I	Normal
II	Loss of fine muscular coordination in one leg, or partial loss of fine muscular coordination in both legs.
III	Loss of fine muscular coordination in one arm or partial loss of fine muscular coordination in both arms.
IV	Loss of fine muscular coordination in both legs, or total loss of one leg.
V	Total loss of one leg and loss of fine muscular coordination of other leg.
VI	Total loss of one arm or loss of fine muscular coordination in both arms, or loss of fine muscular coordination in both legs and partial loss of fine muscular coordination in both arms.
VII	Total loss of both legs.
VIII	Loss of fine muscular coordination in all extremities.
IX	Total loss of both legs and partial loss of fine muscular coordination in both arms.
X	Total loss of both arms or all extremities.

* The loss of fine muscular coordination of an extremity implies that coarse muscular coordination still exists and likewise, the total loss of an extremity implies the absence of both fine and coarse muscular coordination.

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TABLE II

DISABILITY (FUNCTIONAL) GROUPS BASED ON EXTREMITY BEHAVIOR, AVAILABLE FOR ASSIGNMENT TO EXPERIMENTAL WOUNDS (WOUND CLASSES)

ARMS	LEGS		FUNCTIONAL (DISABILITY) GROUPS
=	=	=	I
CATEGORY A Wounds having no effect on extremity function, no matter in what anatomical location the missile strikes			
=	+	=	II
=	†	=	III
=	++	=	IV
†	++	=	XI
CATEGORY B Lower extremity group			
†	=	=	VI
†	=	=	VII
++	=	=	VIII
++	†	=	XIII
CATEGORY C Upper extremity group			
=	††	=	V
††	=	=	IX
†	†	=	X
†	††	=	XII
††	††	=	XIV
=	++	=	XV
+	†	=	XVI

KEY:

= = no effect

+ = loss of fine muscular coordination (weakness), with maintenance of coarse extremity function

++ = total loss of extremity function, both fine and coarse coordination

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Functional Group to which a given wound falls thus depends upon the time that has elapsed since the wound occurred. The times selected by the Biophysics Division are 30 seconds, 5 minutes, 30 seconds, 12 hours, 24 hours, 48 hours, and 5 days. Each wound, among those contemplated through the elements of area of the human body surface, is assessed as falling into one of the ten or sixteen Functional Groups for each of these seven times. Surveying the entire body surface, adding together all the small elements of area into which it has been conceptually divided, and averaging over the different directions of impact, the research workers of the Biophysics Division eventually arrive at a table like Table IV of reference 12, giving the fraction of the total projected body area upon which a hit, by a fragment with specified physical characteristics and striking velocity, would produce wounds in each of the Functional Groups I through X, at each of the seven times after wounding. Thus, for an 0.85-grain spherical steel fragment striking at 3800 feet per second, 2.7% of the projected body area is found to be such as to yield wounds in Functional Group IV twelve hours after wounding; 0.1% of the body area is found to yield wounds in Functional Group V twelve hours after wounding; 9.4% of the area is found to result in wounds in Functional Group VI twelve hours after wounding, etc. After twenty-four hours, the corresponding percentages are different, being then 12.3%, 1.6%, and 6.1% respectively. Table IV of reference 12 actually contains $7 \times 3 \times 10 = 210$ entries in all for the 0.85-grain sphere; corresponding to all combinations of seven times, three striking velocities, and ten Functional Groups. The percentage, of the total projected body area, listed in the table can be interpreted as the probability that if a man is hit at random by a steel sphere of the specified size and striking velocity, the resulting wound will be in the specified Functional Group within the specified time after wounding.

There has next been introduced the concept of four standard stress situations. "Incapacitation" of a soldier refers to his inability to carry out certain duties. To "incapacitate" a soldier means "to deprive him of capacity", and the activities, for the doing of which his capacities have been removed, must be specified before his "incapacitation" can have a specific meaning. The actions with respect to which

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incapacitation should be defined relate to the soldier's combat duties, which are various and depend upon the tactical situation as well as the soldier's military assignment. After consultation with combat officers, the workers in the Biophysics Division selected four important and typical stress situations: the assault, the defense, the reserve, and supply. Infantry soldiers during an assault were considered to require the use of their arms and legs. An ability to run was very desirable, and to move about was necessary. The use of at least one arm was necessary and of both arms was desirable. Without the ability to move about, a soldier could not participate in an assault; and if he could not use hand-operated weapons, his presence and his motion were alike futile. Wounds in Fiege's functional groups I through X were therefore assigned the percentages of incapacitation, or "weights", in Table V of reference 12 which is reprinted below as Table III.

TABLE III

Military Stress Situation	Fiege's Functional Group	Percent Incapacitation
Assault	I, II	0
	III	25
	IV	50
	V, VI	75
	VII - X	100
Defense	I, II	0
	III, IV	25
	V - VII	50
	VIII	75
	IX, X	100
Reserve	I - III	0
	IV	50
	V - X	100
Supply	I, II	0
	III - X	100

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In references 12 and 13 the word "assault" is described as "offense". The authors here use the word "assault", as suggested to them privately by Colonel A. R. Del Campo, because they believe it to correspond more closely than the word "offense" to the stress situation that was contemplated by the Biophysics Division. It will be noticed that wounds in Functional Groups I and II are considered not to incapacitate the assault soldier at all, while wounds in the higher Functional Groups incapacitate him by 25%, 50%, 75%, or 100%. The 100% incapacitation corresponds to Functional Group VII, VIII, IX, and X, and thus involves the total loss of the use of both legs, the total loss of the use of both arms, or the loss of fine muscular coordination in all extremities.

In the same way, a standard "defense" situation was considered in which the soldier would not need to move so long as he could operate hand weapons. Locomotion, although desirable, was not necessary to the performance of some valuable duties. The notion involved is that an enemy soldier on the defensive, attacked by our troops, can be effective in helping to stop our advance without the need for his moving, so long as he can operate weapons. It will be noticed that different percentages of incapacitation were assigned to the various Functional Groups in the "defense" situation in the table, from those in the "assault" situation.

The third stress situation considered was that of troops held in "reserve". These reserve troops were conceived to be troops ready for combat and close to combat but not yet committed to combat. They are in battalion or divisional reserve, and once committed have then to participate either in an assault, or in defense. It seems reasonable that such troops, required to be capable of more numerous possible activities than troops already specifically committed to assault or defense, will in general be more vulnerable to incapacitation by wounds than troops in "assault" or "defense" situations.

The final stress situation was that of "supply", which included vehicle drivers, ammunition handlers, and a variety of other personnel, possibly far from combat. The Biophysics Division considered that such troops are very vulnerable to incapacitation; they need to use all extremities, and any wounds in Fiege's Functional Groups III through X are considered to incapacitate them completely.

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The percentages of incapacitation assigned in reference 13 to Gould's sixteen Disability Groups are as follows:

TABLE IV

Gould's Disability Group	Percent Incapacitation			
	Assault	Defense	Reserve	Supply
I	0	0	0	0
II	50	25	75	25
III	75	25	100	50
IV	100	50	100	100
V	100	50	100	100
VI	50	25	75	25
VII	75	50	100	50
VIII	75	75	100	75
IX	100	100	100	100
X	75	75	100	75
XI	100	75	100	100
XII	100	75	100	100
XIII	100	100	100	100
XIV	100	100	100	100
XV	100	50	100	100
XVI	75	50	100	75

The percentages of incapacitation, assigned to the various Functional or Disability Groups in the different military stress situations, involved a combination of tactical and medical judgements and one might regard some of the percentages as somewhat doubtful or at least debatable. However, any different percentages of incapacitation that might have been assigned to the same Functional or Disability Groups would also have been somewhat doubtful and debatable, and the percentages actually chosen appear to the authors to have been reasonable. A more precise specification of duties might have rendered the percentages more certain. But then either more than four stress situations would have had to be considered, or else some of the more frequent and typical military assignments would have been overlooked. The choice of the four stress situations "assault", "defense", "reserve" and "supply" are thought by the authors to have been reasonable, and they think that military functions different from these can perhaps often be considered, without much loss of accuracy, to involve a degree of vulnerability to incapacitation comparable to some one of the four specified stress situations. Thus, field artillery personnel must move about and use their hands, and are of no use to their side unless they can do both of

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these things. It would thus appear that field artillery troops at work in their batteries can be considered, incapacitation-wise, to be equivalent to "supply" troops.

Dr. Dziemian has estimated the percentages of the total body area on which hits, by a caliber 0.30 rifle-bullet Ball M2 would produce, within various times, wounds falling into Gould's Disability Groups I through XVI. The range is from 100 to 300 yards, and the initial velocity is about 2700 ft per sec. Table V shows, in rows corresponding to Gould's Disability Groups, the percentages of total body area for times of 30 seconds, 5 minutes, and 30 minutes after wounding. Thus the number 4.7 in row XI in the column headed "5 minutes" indicates that 4.7 percent of the body area of a man is such that a hit on it by a rifle bullet will on the average produce a type XI Disability Group in five minutes. These percentages can alternatively be regarded as the probabilities that random hits will produce the various Disability Groups in the various times.

3. RELATION OF THE FIEGE FUNCTIONAL GROUPS TO THE GOULD DISABILITY GROUPS

The incapacitating power of darts¹⁴ has been evaluated by comparison with 0.85 - grain spheres, and hence rests on the Fiege groups. The bullet data are urgently needed to compare the effectiveness of dart-firing weapons and rifles, but the bullet data in Table V rest on the Gould groups. Hence either the 0.85 - grain data must be converted to the Gould basis, or the bullet data must be converted to the Fiege basis.

A study of Tables I and II shows that each Gould group corresponds at the most to one Fiege group but that some Fiege groups correspond to more than one Gould group. It appears to be impossible, without medical reassessment, to re-evaluate the incapacitating power of the 0.85-grain sphere in terms of the Gould groups, because it is uncertain into which Gould group a particular Fiege assessment will fall. To obtain probabilities of incapacitation on a consistent basis, it is therefore necessary to convert the Gould groups into Fiege groups; this can be done by a process that is abstract rather than medical since it largely involves the pooling

¹⁴ T. E. Sterne, "A Provisional Criterion for Incapacitation by a Dart: II (U)". BRL Memorandum Report No. 918, August 1955.

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¹⁴ T. E. Sterne, "A Provisional Criterion for Incapacitation by a Dart: II (U)". BRL Memorandum Report No. 918, August 1955.

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TABLE VI

THE RELATION OF GOULD'S TO FIEGE'S GROUPS, WITH FIEGE'S
PROBABILITIES OF INCAPACITATION

Gould's Disability Group	Fiege's Functional Group	Probabilities of Incapacitation in the Tactical Stress Situations			
		Assault	Defense	Reserve	Supply
I	I	0	0	0	0
II	II	0	0	0	0
III	IV	50	25	50	100
IV	IV	50	25	50	100
V	VII	100	50	100	100
VI	III	25	25	0	100
VII	VI	75	50	100	100
VIII	VI	75	50	100	100
IX	X	100	100	100	100
X	VIII	100	75	100	100
XI	IX?	100	100	100	100
XII	IX	100	100	100	100
XIII	IX?	100	100	100	100
XIV	X	100	100	100	100
XV	V	75	50	100	100
XVI	VI?	75	50	100	100

TABLE VII

PROVISIONAL PROBABILITIES, THAT RANDOM HITS BY CALIBER 0.30
RIFLE-BULLETS BALL M2 WILL INCAPACITATE, WITHIN 300 YARDS

Stress Situation of Target Troops	Time after Wounding		
	30 seconds	5 minutes	30 minutes
Assault	.61	.73	.89
Defense	.49	.65	.84
Reserve	.64	.74	.90
Supply	.79	.86	.93

SECRET

With the probabilities G_1 in Table V that bullet-hits will produce the various Gould Disability Groups in the various times, and the probabilities P_1 in Table VI of incapacitation*, one obtains the probabilities P of Table VII that a random hit by a caliber 0.30

$$P = G_{I I} P_{I I} + G_{II II} P_{II II} + G_{III III} P_{III III} + \dots + G_{XVI XVI} P_{XVI XVI}$$

rifle-bullet, Ball M2, on a man in any one of the four stress situations will incapacitate him within 30 seconds, 5 minutes, or 30 minutes at ranges up to 300 yards.

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* All results relating to the incapacitating power of fragments will probably have to be transformed to the basis of the Fiege Groups because the 0.85-grain fragment was evaluated in the Fiege system while fragments later worked on have been evaluated on the Gould system. It is hoped that Table VI in the present report may assist in the transformation of all incapacitation data to the Fiege system.